

PL-TR-94-2259

SSS-DPR-94-14823

## Development of a Geophysical Data Fusion System for Assessment and Remediation Studies of Polluted Groundwater Aquifers

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October, 1994

Scientific Report No. 1

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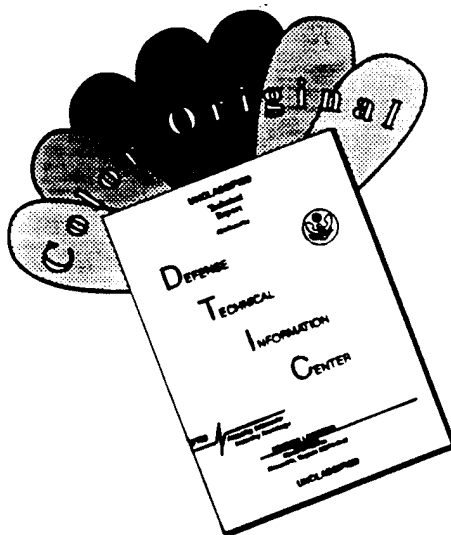
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Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE October 1994	3. REPORT TYPE AND DATES COVERED Scientific No. 1	
4. TITLE AND SUBTITLE Development of a Geophysical Data Fusion System for Assessment and Remediation Studies of Polluted Groundwater Aquifers			5. FUNDING NUMBERS PE 62101F PR 7600 TA GN WU AB	
6. AUTHOR(S) J. R. Murphy D. C. O'Neill B. W. Barker			Contract F19628-93-C-0113	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Maxwell Laboratories, Inc. S-CUBED Division PO Box 1620 La Jolla, CA 92038-1620			8. PERFORMING ORGANIZATION REPORT NUMBER  SSS-DPR-94-14823	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Phillips Laboratory 29 Randolph Road Hanscom AFB, MA 01731-3010  Contract Manager: James Lewkowicz/GPEH			10. SPONSORING/MONITORING AGENCY REPORT NUMBER  PL-TR-94-2259	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT  Approved for public release; distribution unlimited			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words)  The research described in this report is directed toward the development of a workstation-based data management, analysis and visualization system which can be used to improve the Air Force's capability to evaluate site specific environmental hazards. The initial prototype system described in this report is directed toward a specific application to the Massachusetts Military Reservation (formerly Otis Air Force Base) on Cape Cod, Massachusetts. This system integrates a comprehensive, on-line environmental database for the site together with a map-based graphical user interface which facilitates analyst access to the databases and analysis tools needed to characterize the subsurface geologic and hydrologic environments at the site.				
14. SUBJECT TERMS Geophysics Data Fusion			15. NUMBER OF PAGES 36	
MMR Otis AFB			16. PRICE CODE	
Seismic SPOT				
17. SECURITY CLASSIFICATION OF REPORT  Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE  Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT  Unclassified	20. LIMITATION OF ABSTRACT  SAR	



## I. INTRODUCTION

The Air Force has recently adopted a goal to insure that all of their facilities shall be environmentally clean by the year 2005. A significant element of the program which is being designed to achieve this goal is the development of new geophysical technology for characterizing hazardous waste sites, with particular emphasis on the assessment and remediation of any polluted groundwater aquifers which may exist at the wide variety of Air Force facilities which are distributed throughout the U.S. This is a significant challenge in that these sites represent a great diversity of geological and hydrological environments and, consequently, their effective characterization is likely to involve many different types of information and geophysical survey data. Thus, an ability to efficiently integrate or fuse all of these disparate data and analysis results will be an important component of any successful environmental assessment program.

The research described in this report has the objective of improving the Air Force's capability to evaluate site specific environmental hazards through the development of an innovative, workstation-based data management, analysis and visualization system which will permit an analyst to easily apply a wide variety of site information and geophysical analysis tools to the assessment of specific sites. The ultimate goal is to develop a system which will integrate a comprehensive, on-line environmental database for a selected site together with a map-based graphical user interface which facilitates analyst access to the databases and analysis tools, an analysis module containing state-of-the-art hydrological and geophysical theoretical simulation models and a visualization system for the display and evaluation of data and model simulation results within a single, homogeneous analysis environment.

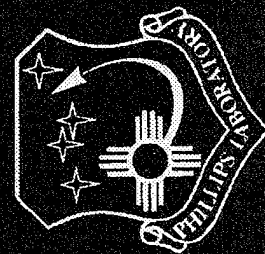
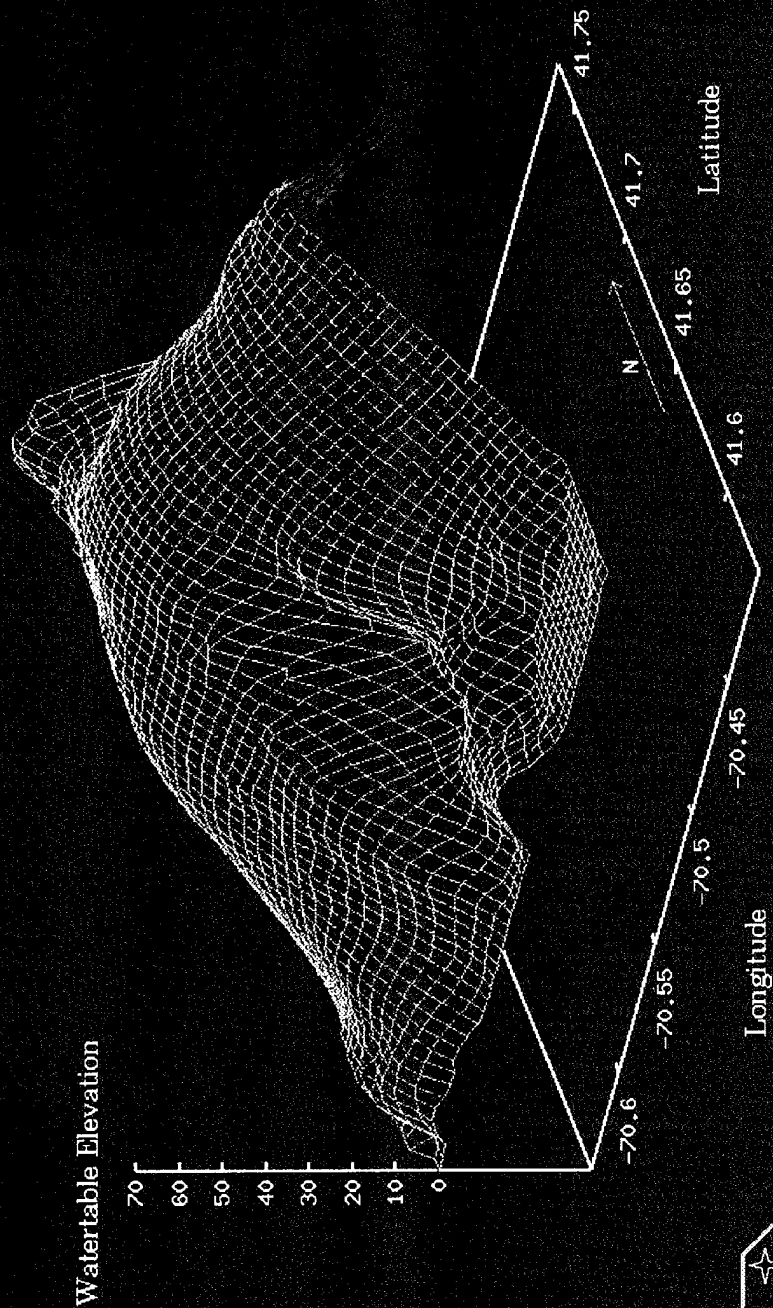
The initial prototype system described in this report is directed toward a specific application to the Massachusetts Military Reservation (formerly

Otis Air Force Base) located on Cape Cod, Massachusetts. This site was chosen because environmental restoration studies have been on-going at this location for more than 10 years and, consequently, a wide variety of geotechnical data are already available for demonstration of system capabilities. Moreover, its proximity to the Phillips Laboratory Geophysics Directorate at Hanscom Air Force Base in Massachusetts facilitates interaction with base personnel and acquisition of supplemental data.

Some of the capabilities and functionality of the prototype Geophysical Data Fusion System (GDFS) are graphically illustrated in the following pages where displays of the workstation screens encountered by an analyst in a typical processing session are presented.

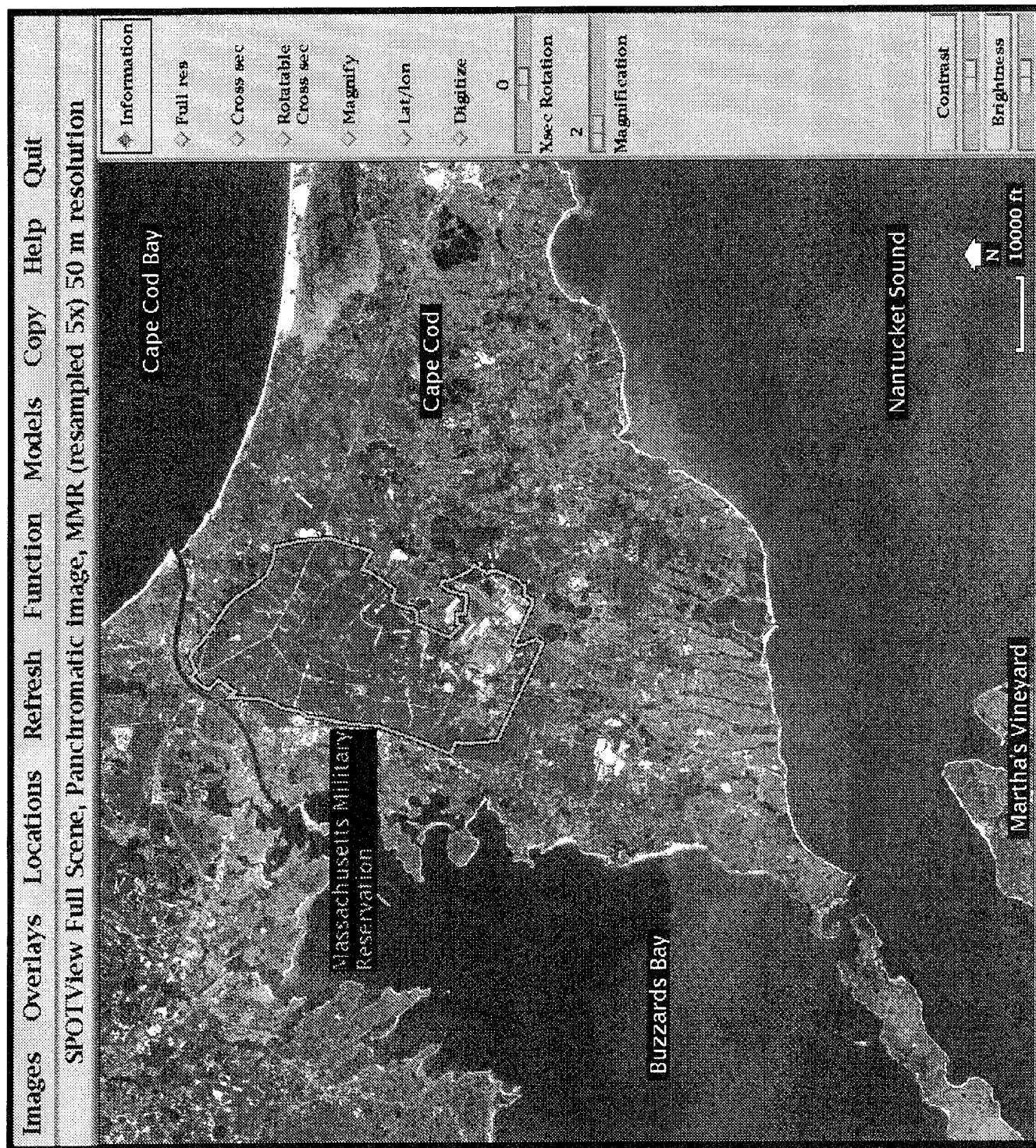
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# Geophysical Data Fusion System



U. S. Air Force Installation Restoration Program  
Massachusetts Military Reservation

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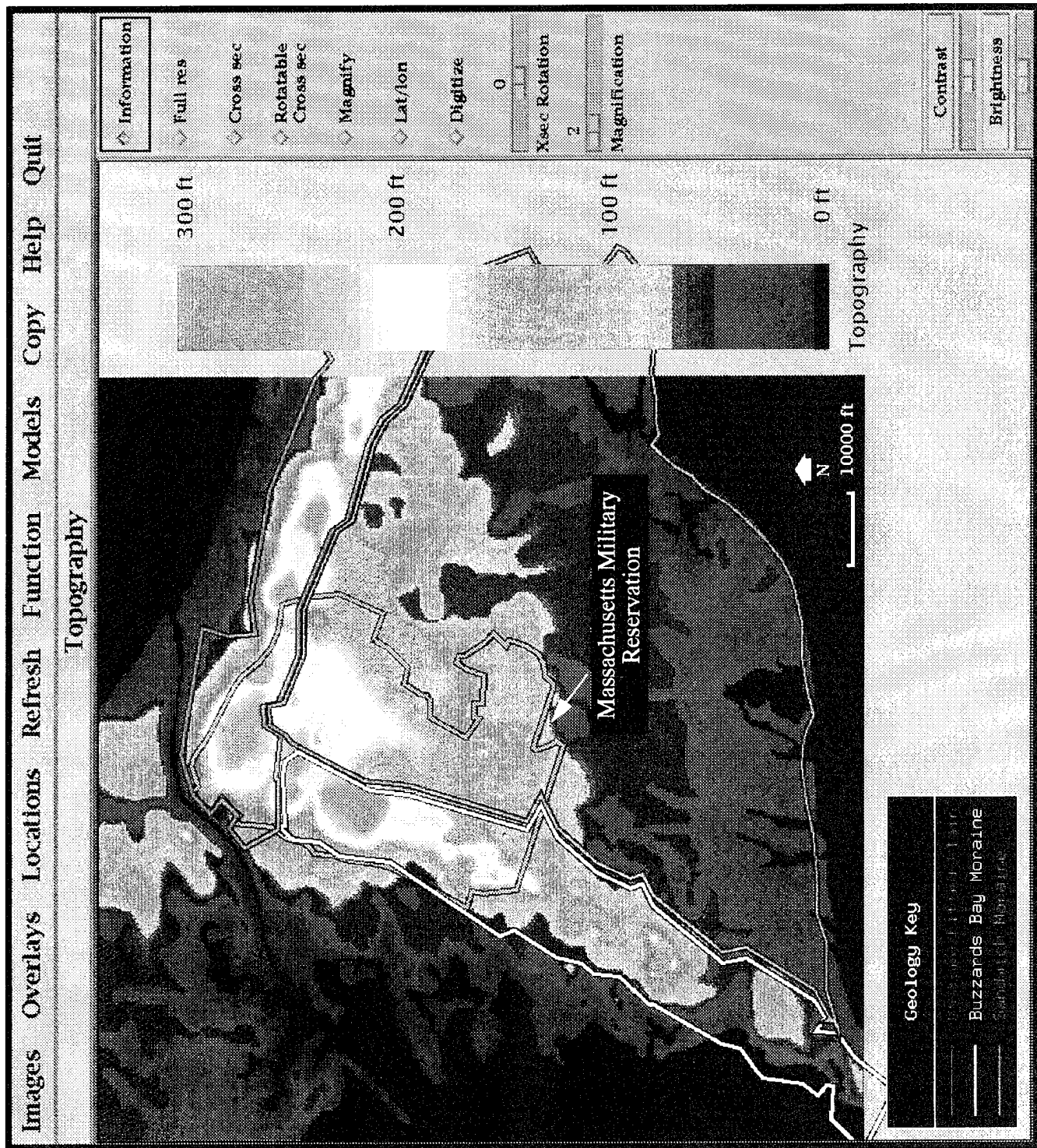


Compressed SPOT satellite image of western Cape Cod ( 50m resolution ) with superimposed boundary of the Massachusetts Military Reservation ( MMR ).

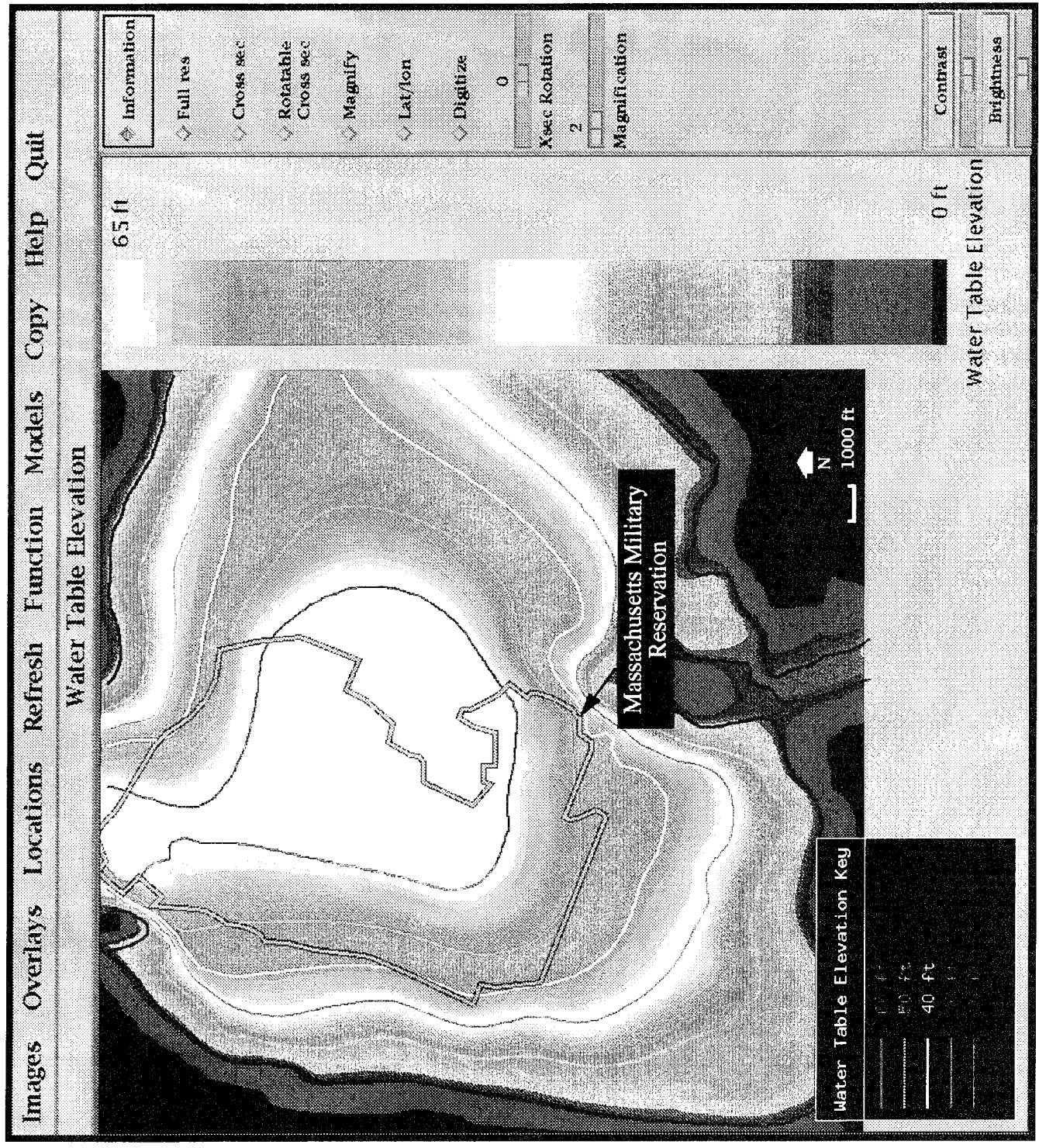


Compressed SPOT satellite image of western Cape Cod ( 50m resolution )  
with superimposed surface geologic map and MMR boundary.

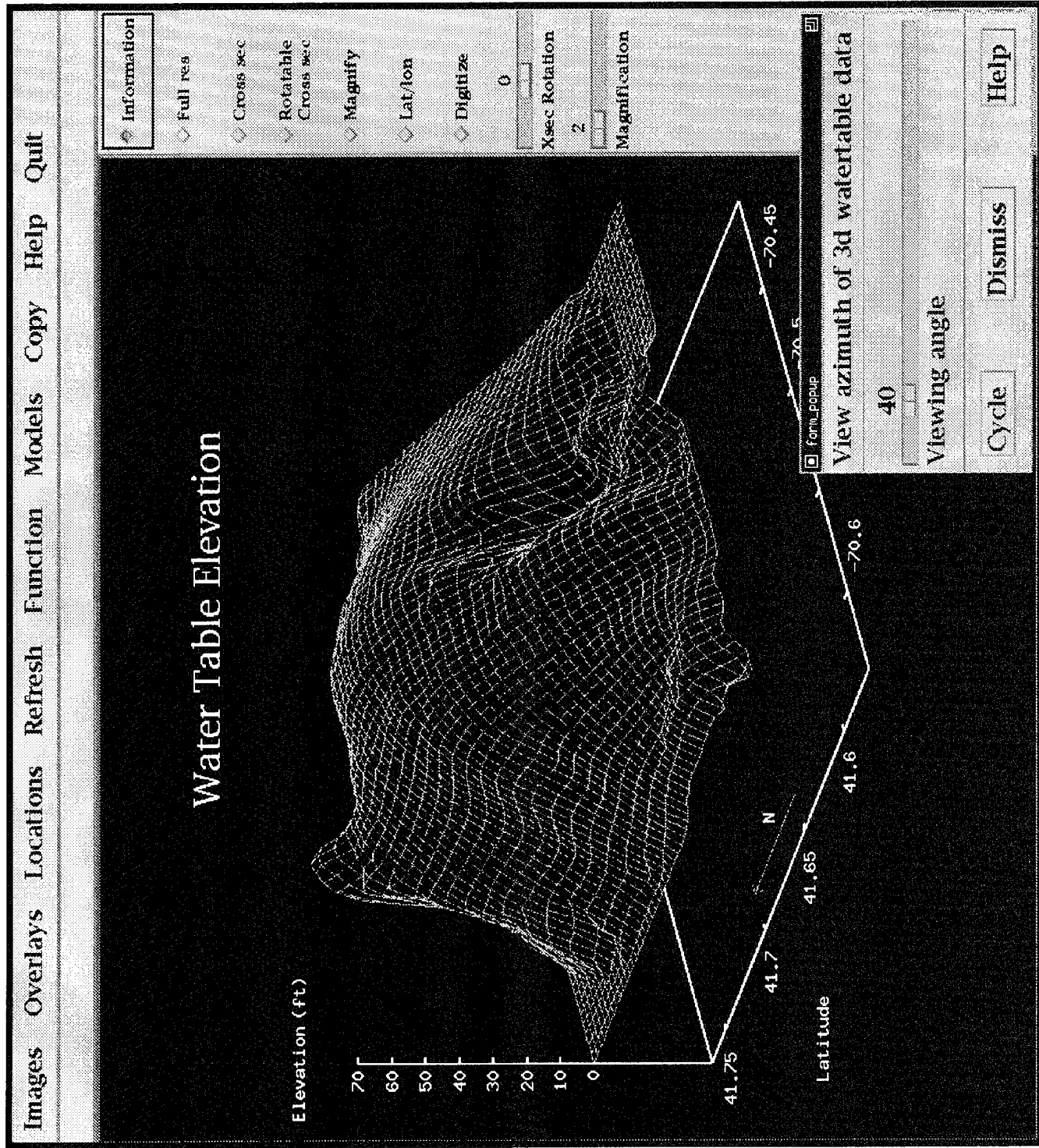




Color-coded representation of Defense Mapping Agency (DMA) topographic data for western Cape Cod with superimposed surface geologic map and MMR boundary.

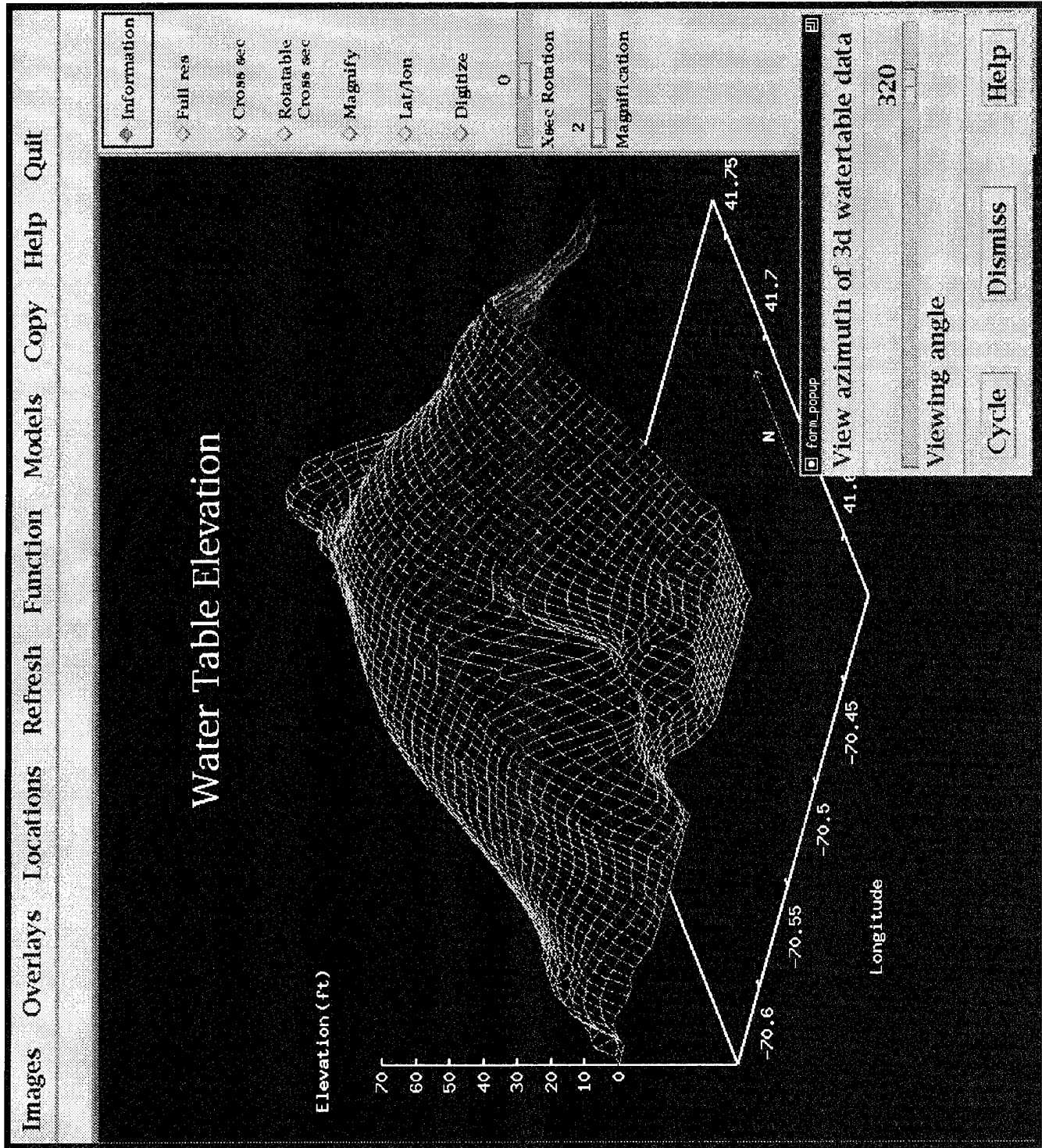


Color-coded representation of depth to water table for western Cape Cod with superimposed MMR boundary.

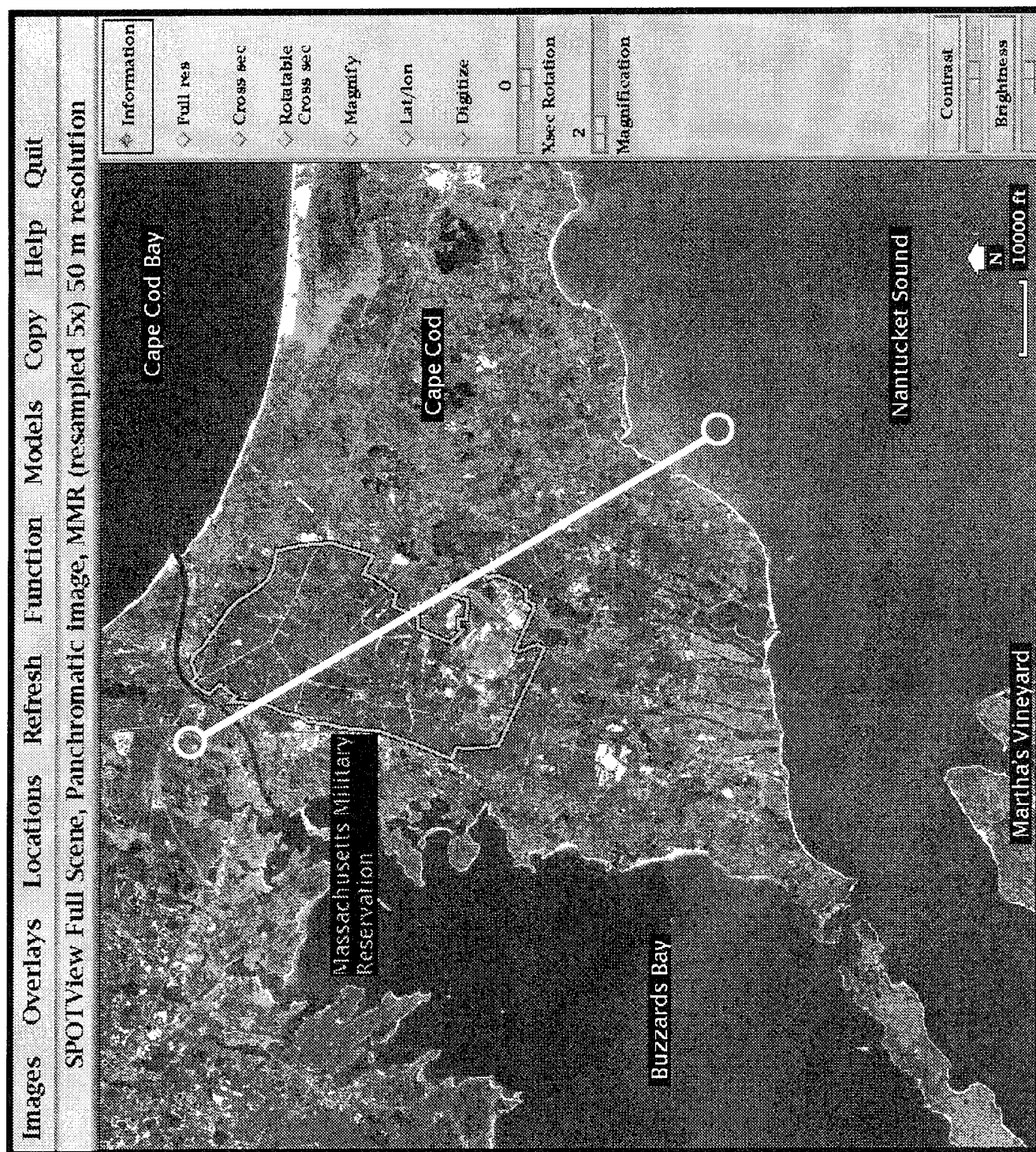


Three-dimensional wireframe representation of depth to water table for western Cape Cod; view looking northeast from an elevated point southwest of MMR.

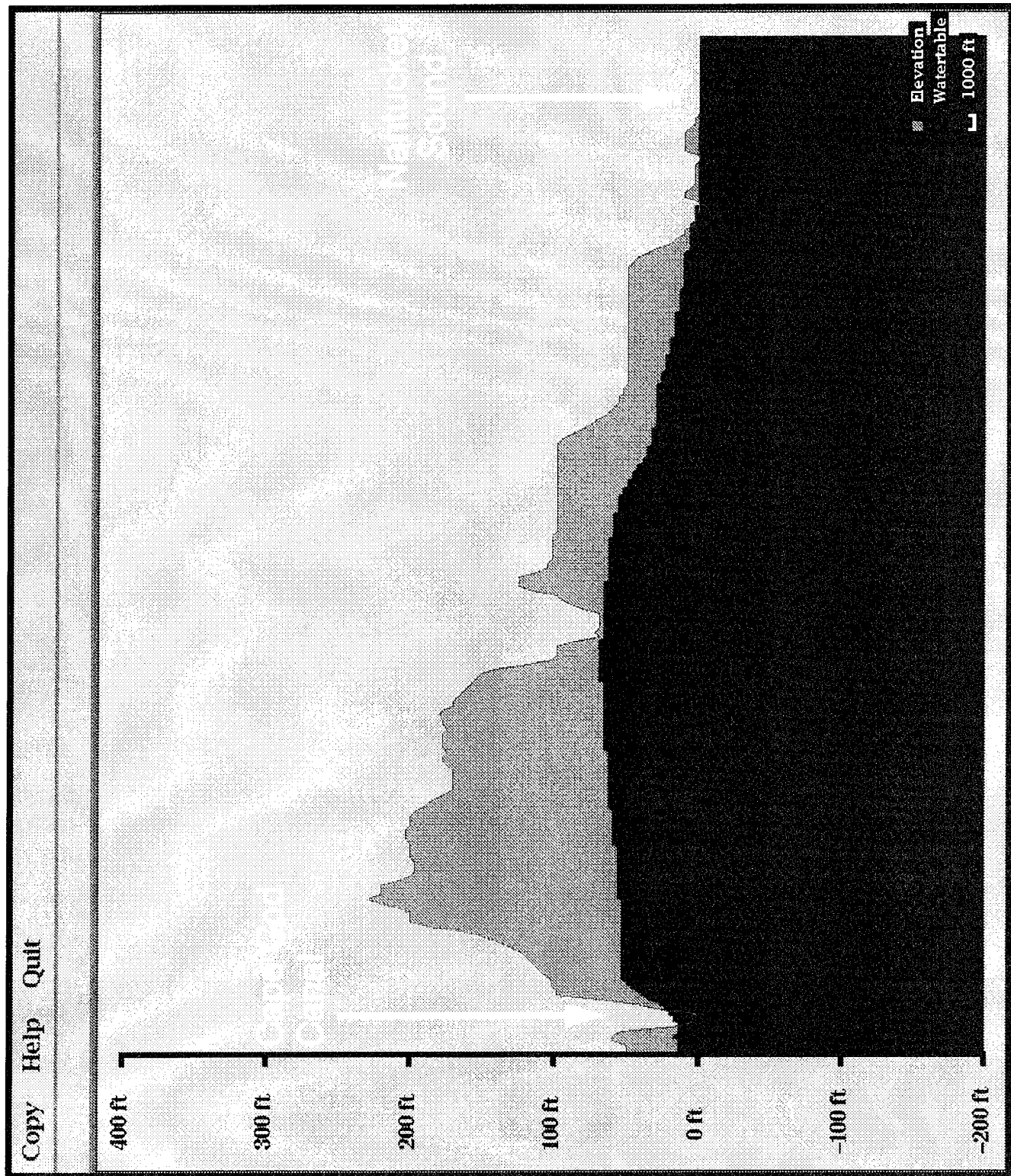




Three-dimensional wireframe representation of depth to water table for western Cape Cod; view looking northwest from an elevated point southeast of MMR.

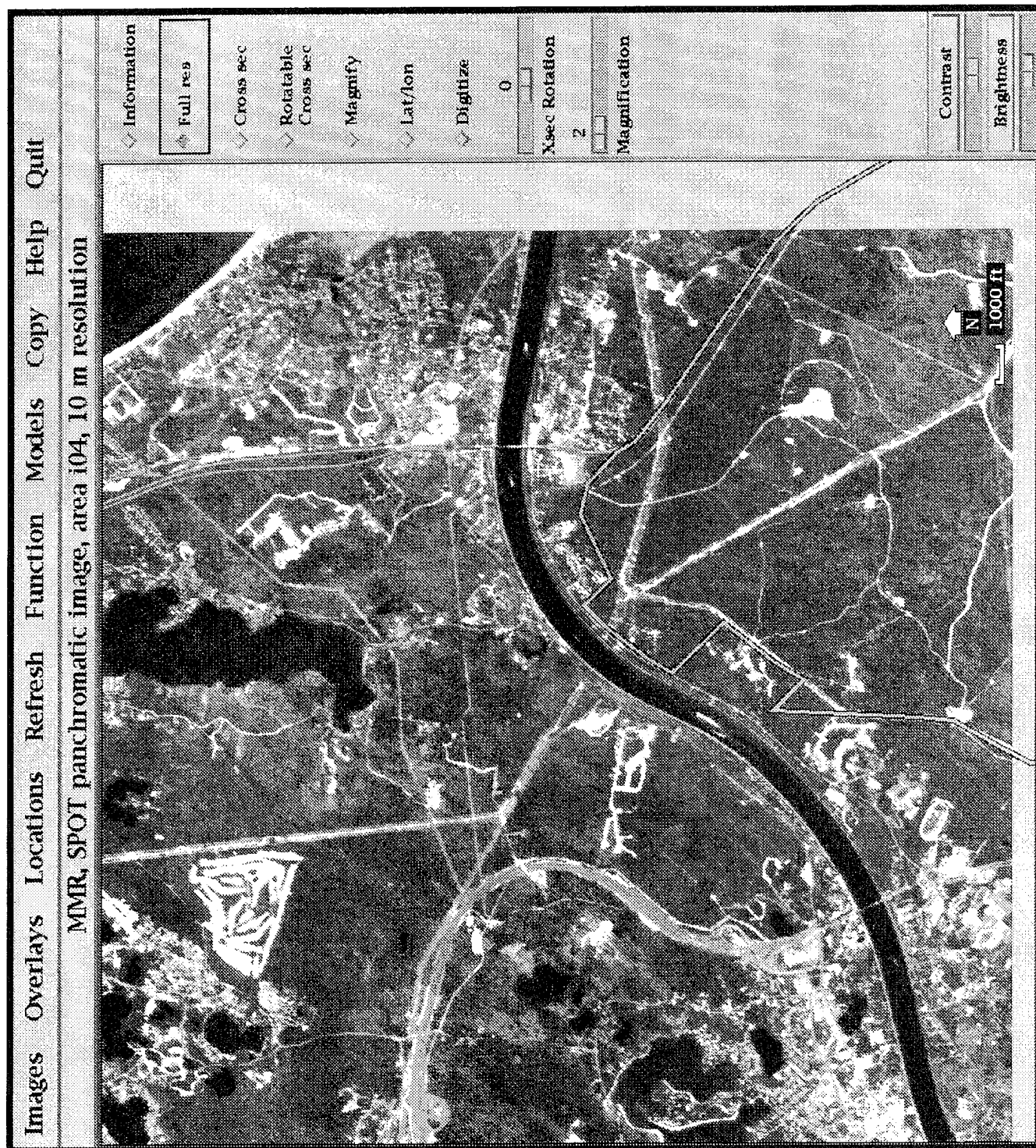


Interactively selected line running southeast across the Cape Cod Canal and MMR to Nantucket Sound.

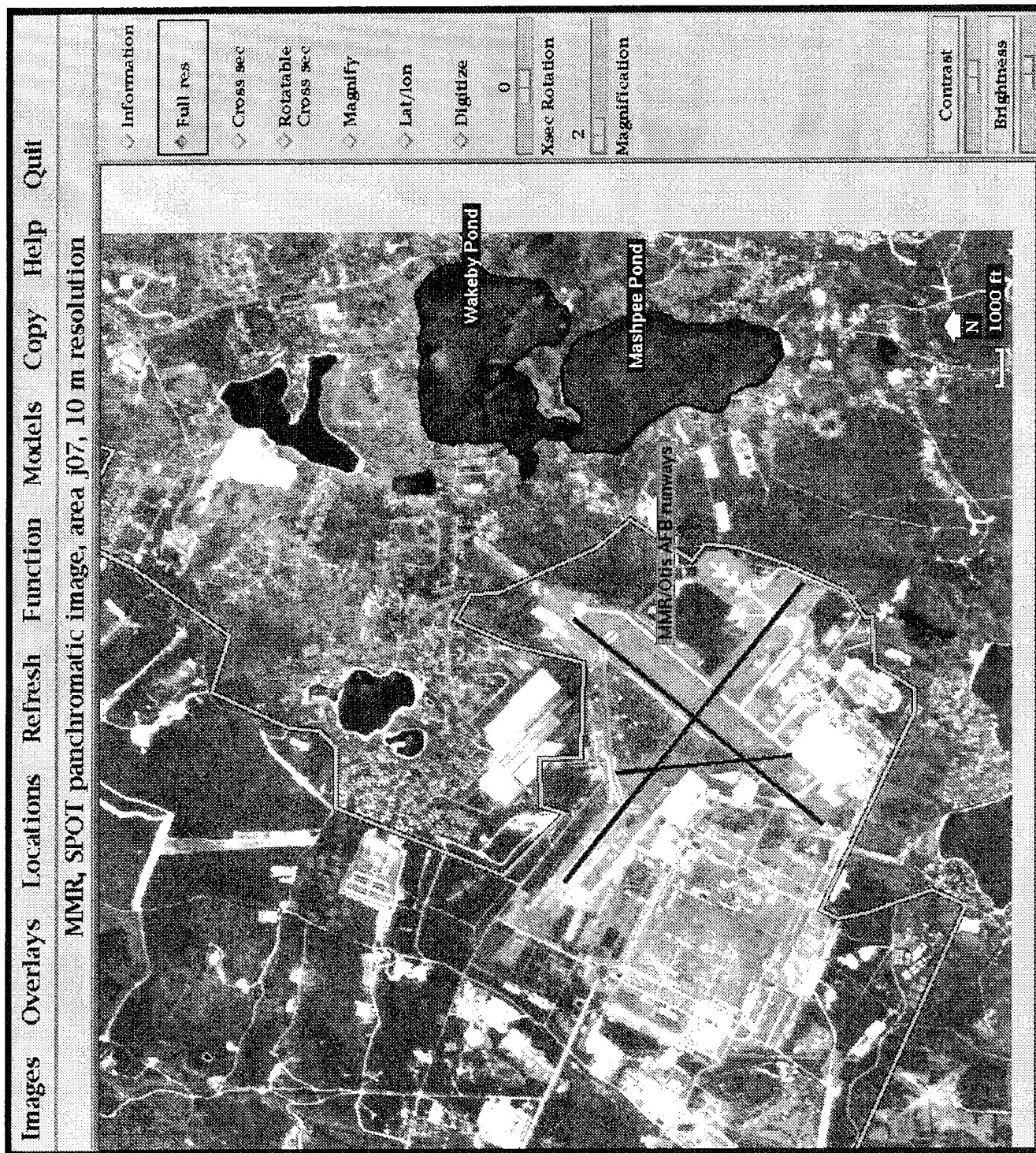


Vertical subsurface section along the interactively selected line from the previous figure showing the variations in surface topography and depth to water table (orange/blue boundary) along that line.

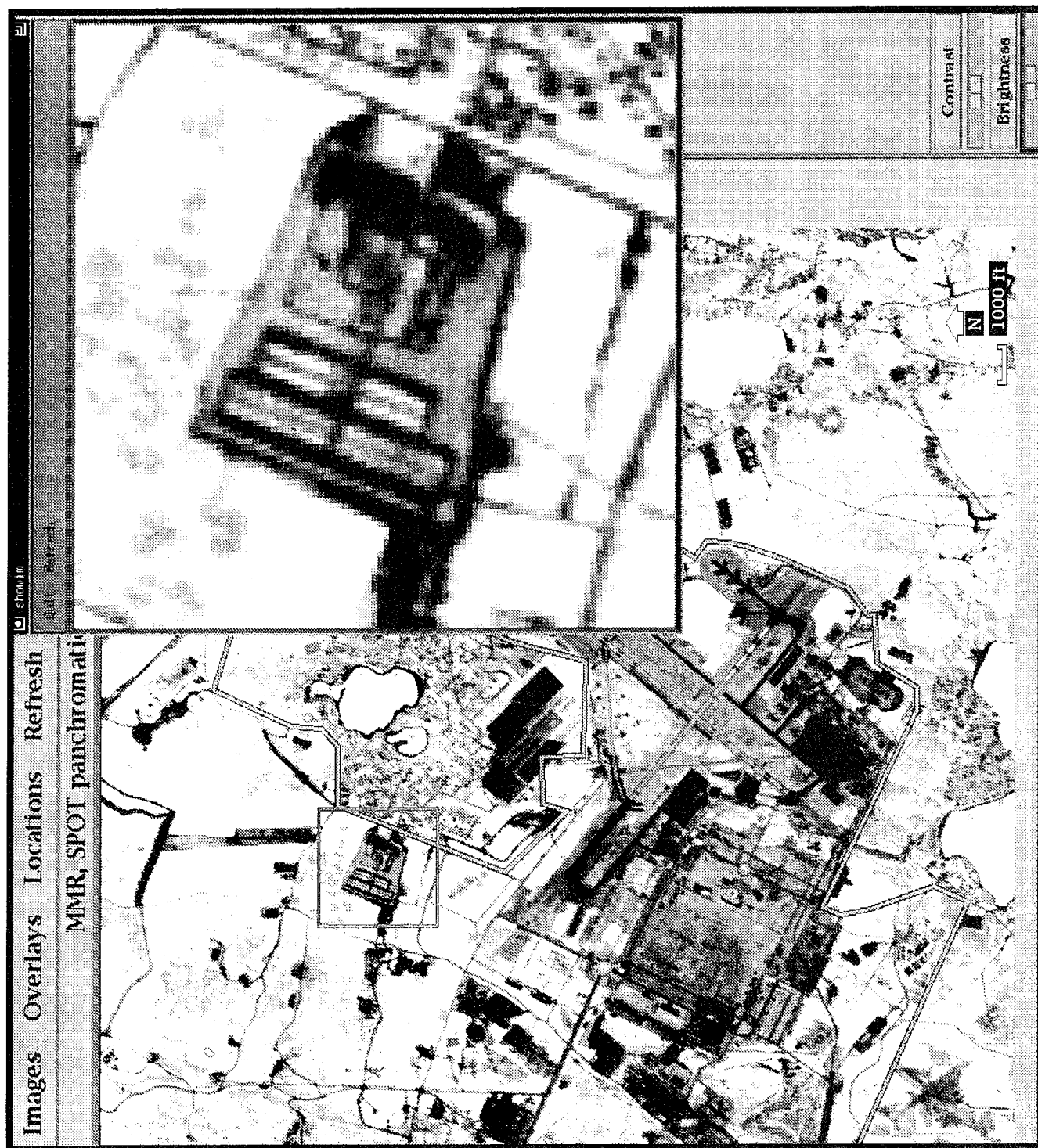




Full resolution (10m) SPOT image of central portion of Cape Cod Canal with superimposed northwestern boundary of MMR. Note that the canal bridges and ships in the canal are readily identifiable at this scale.

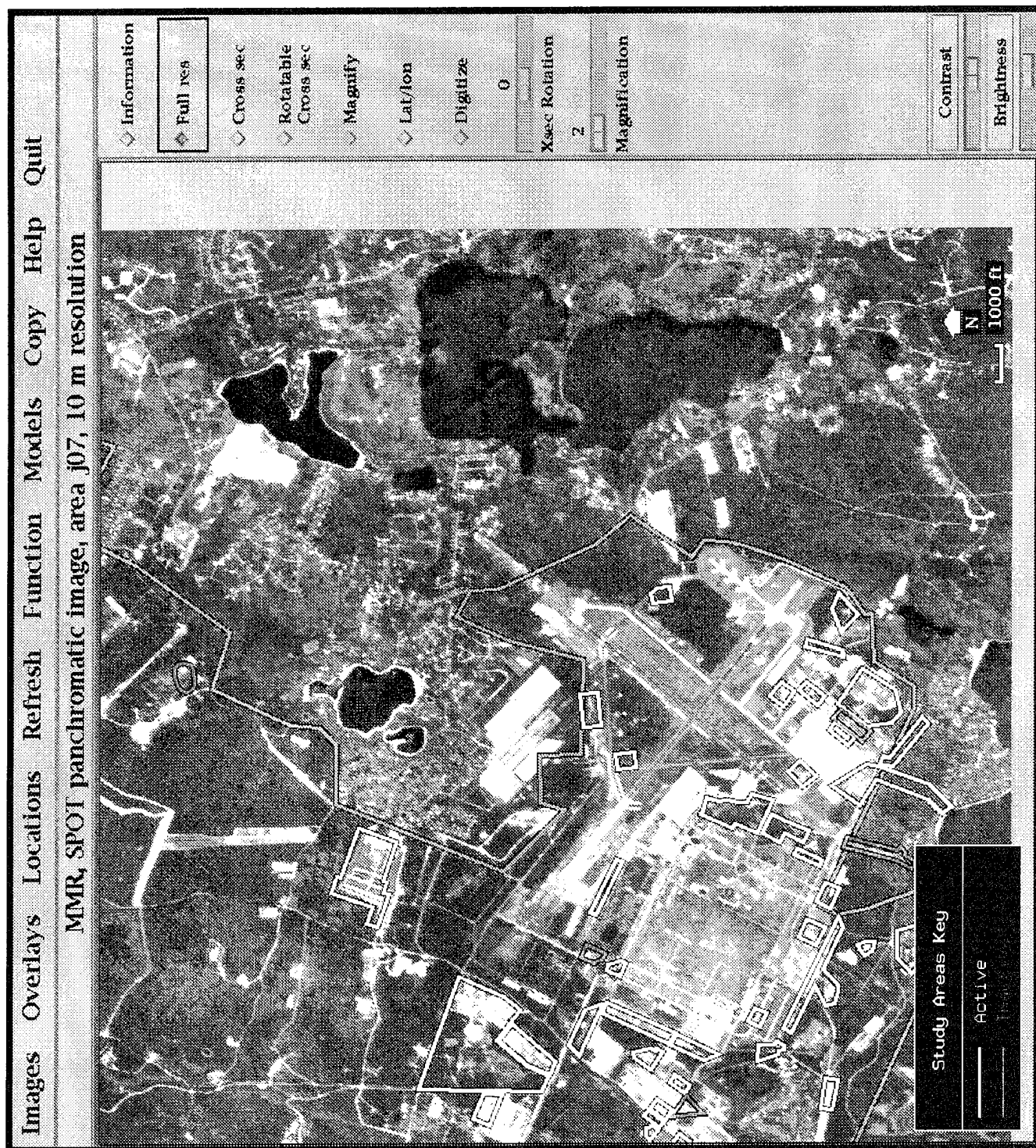


Full resolution (10m) SPOT image of southeast corner of MMR which encompasses most of the base facilities. The locations of the MMR boundary and several natural and man-made features in the area have been superimposed to orient the viewer.



Full resolution SPOT image of the southeast corner of MMR illustrating the capabilities for the system user to interactively modify the contrast and brightness of the image and to magnify selected portions of the image.





Full resolution SPOT image of the southeast corner of MMR with superimposed MMR boundary and outlines of areas being studied as possible sources of contamination.

## Information

 Help

AOC. SD-2

Runway/Aircraft Maintenance Storm Drainage Ditch No.2; AOC FS-6: Airfield Apron Fuel Spill; AOC FS-8: Airfield Apron Fuel Spill; PFSA; AOC FS-10: Fuel Spill; and AOC FS-11: Fuel Spill. AOC SD-2 (including Fuel Spills FS-6 and FS-8) is the storm drainage ditch beginning at the terminus of two 42-inch storm drains and an oil/water separator located immediately south of South Outer Road. The storm drainage ditch extends approximately 2,500 feet south-southwest from the oil/water separator and discharges to Ashumet Pond. The storm sewer line discharging to AOC SD-2 receives runoff water from the Petroleum Fuels Storage Area (PFSA), aircraft maintenance ramp, hangar, nosedocks, and spills and releases of solvents, fuels, or other chemical products, including Fuel Spills FS-6 and FS-8. Fuel Spill FS-6 is the site of an estimated 15,000-gallon EC-121 aviation gasoline (AVIAS) fuel spill on the aircraft apron in the early 1960s. Fuel Spill FS-8 is the site of an estimated 8,000-gallon fuel spill resulting from an EC-121 aircraft fire in the 1960's. Both FS-6 and FS-8 spills were reportedly washed directly off the aircraft maintenance ramp by fire crews into the storm sewer system discharging to AOC SD-2.

AOC SD-2 and its vicinity were characterized during the Task 2-1, Task 2-5, Task 2-3B, and Task 2-5 studies (E. C. Jordan Co., 1988b, 1990a, 1990g, and 1990j). These studies included sediment sampling, drilling

**Crit**

## Study Areas Key

Active

### Contrast

Brightline 98

Example of online information documenting investigations of Study Area SD-2, which was automatically extracted from the database and displayed by clicking within the displayed SD-2 area outline with the mouse.



# REFLECTIONS

AEB Environmental Services, Inc. (1991a), "Engineering Evaluation/ Cost Analysis for the CS-4, FS-25, and FTA-1 Study Areas Removal Installation Restoration Program, Massachusetts Military Reservation; prepared for HAZWRAP, Portland, Maine; June 1991.

ABE Environmental Services, Inc. (1991b), "Remedial Investigation Field Sampling and Analysis Plan, Priority 1 Areas of Contamination, Task 2-5C"; Installation Restoration Program, Massachusetts Military Reservation, prepared for HAZWRAP; Portland, Maine; August 1991.

Army Environmental Hygiene Agency (AEHA) (1986). "Geohydrologic Study No. 38-26-0500-86, Camp Edwards, Massachusetts; July 8-20 and September 9-17, 1985"; April 1986.

Bolton, H. S., R. J. Breteler, B. W. Vigon, J. A. Scanlon, and S. L. Clark (1985), "National Perspective of Sediment Quality"; USEPA Office of Water Regulations and Standards; Washington, DC; USEPA 68-01-6986, May 1985.

Department of the Air Force (1985), "Air Force Installation Restoration Program Management Guidance"; Air Force Engineering and Services Center, Tyndall Air Force Base, Florida, July 1985.

Quit

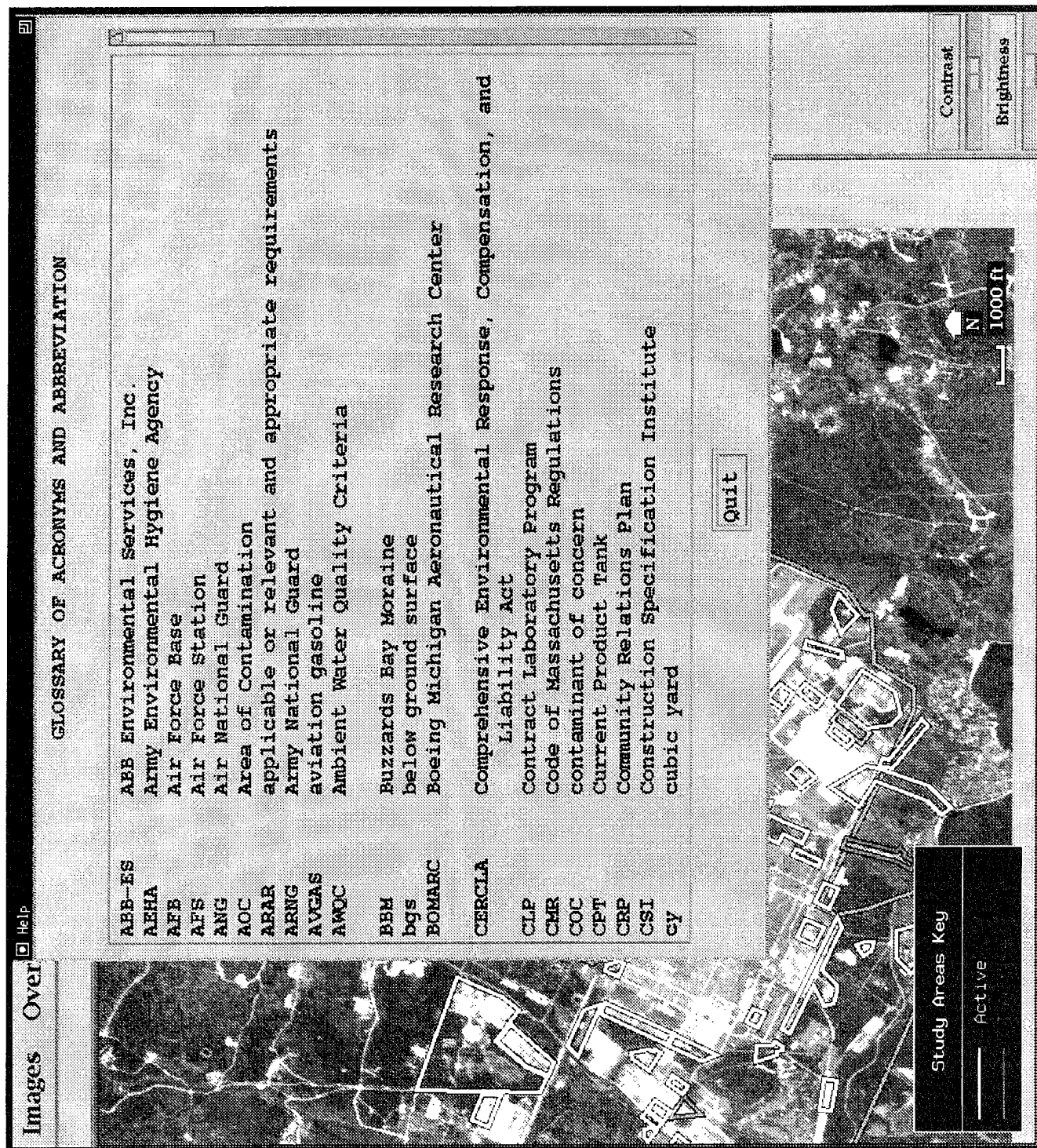


## Study Areas Key

Active

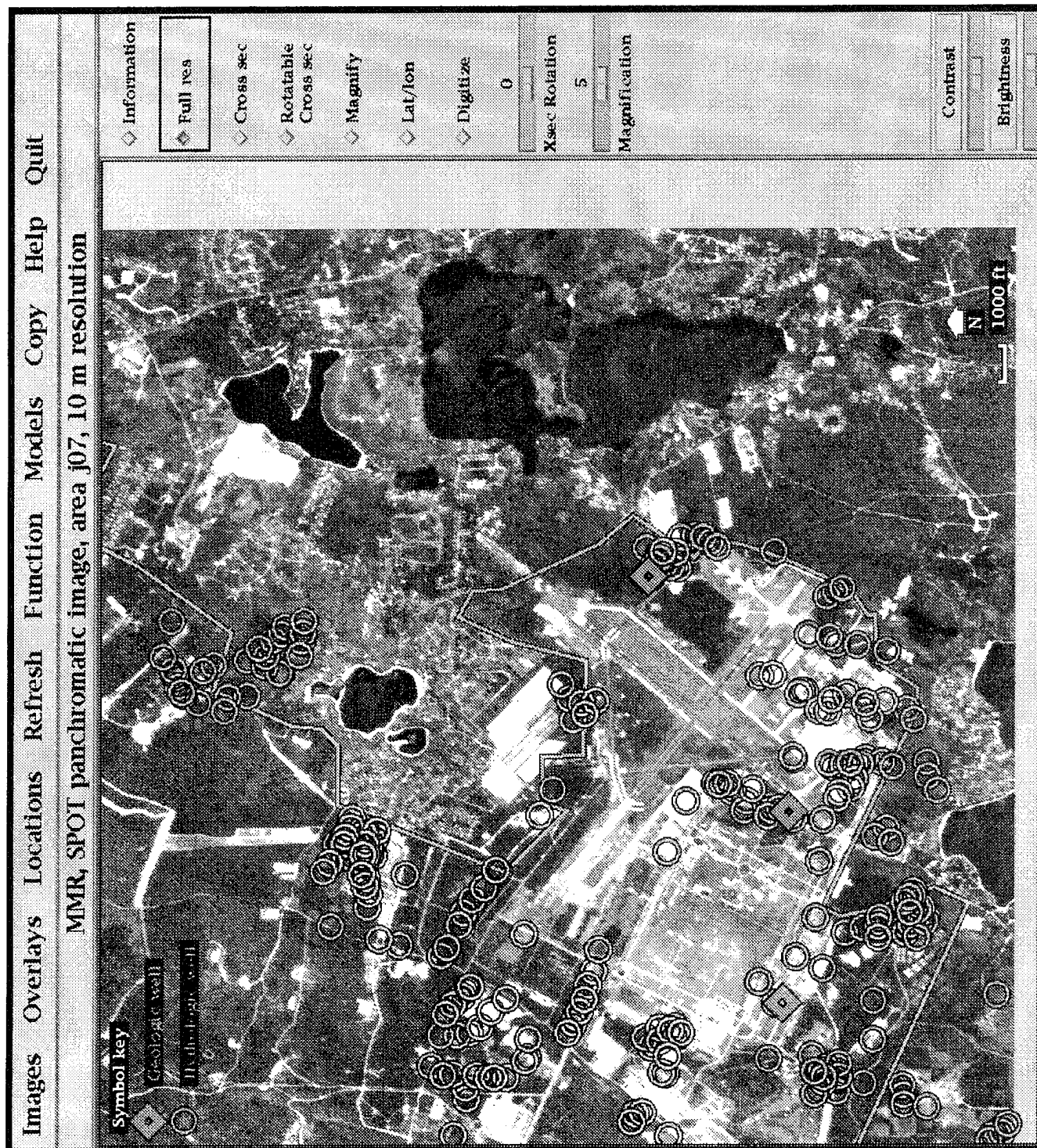
### Contrast

Brightmead

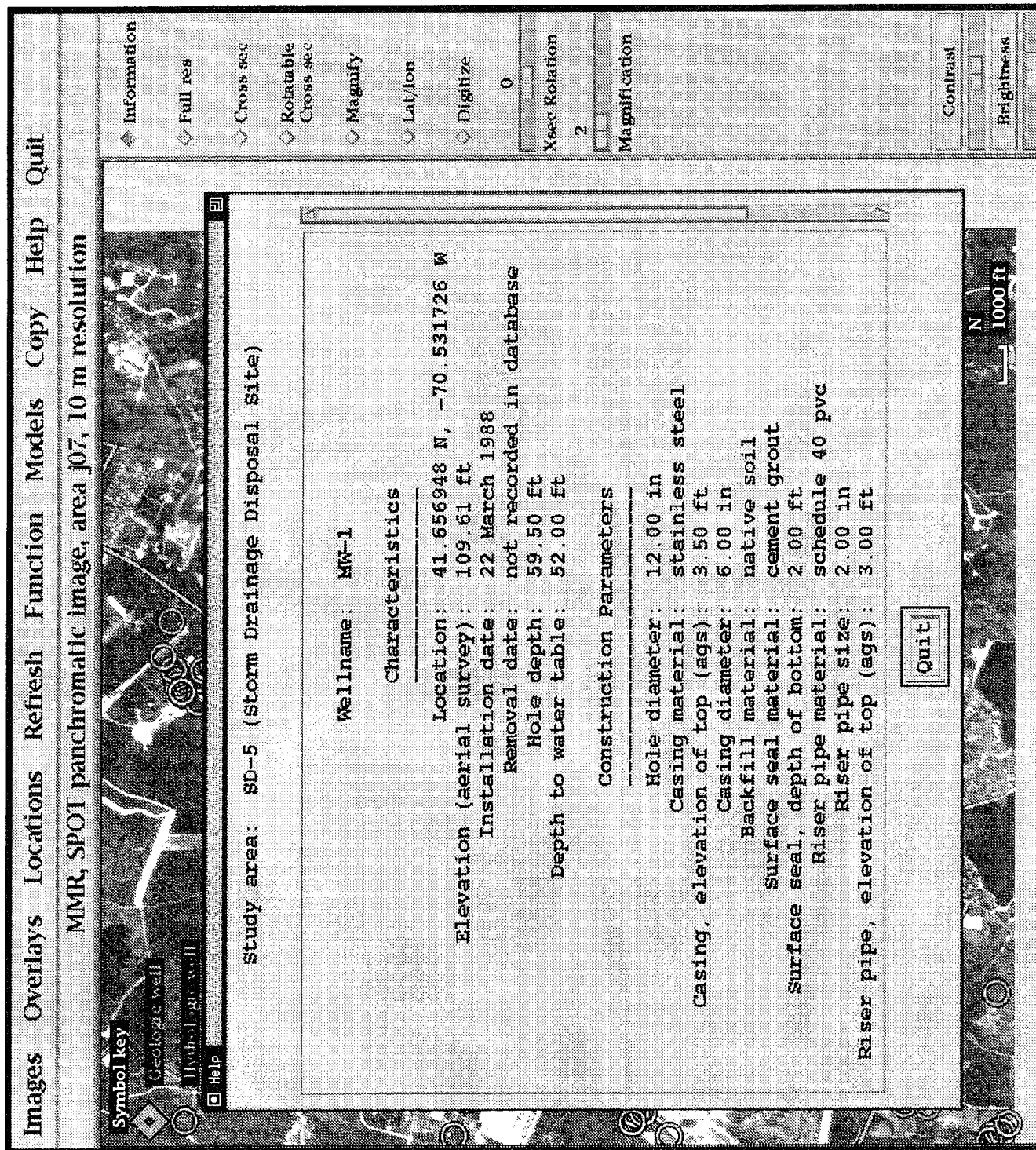


Sample of online file of MMR acronyms and abbreviations which can be accessed from the system HELP menu.

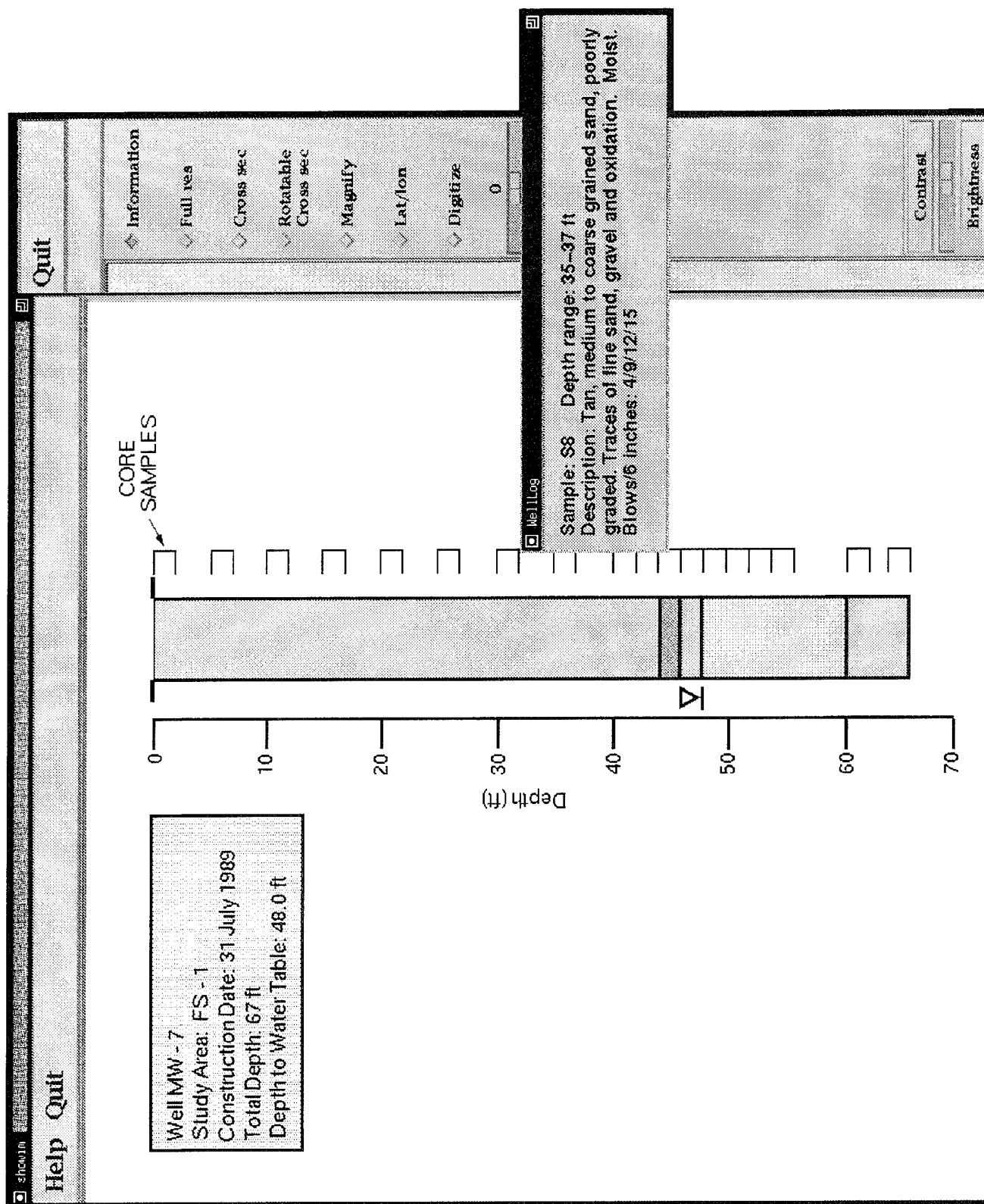




Full resolution SPOT image of the southeast corner of MMR with superimposed MMR boundary and locations of exploratory hydrologic and geologic wells in the area.

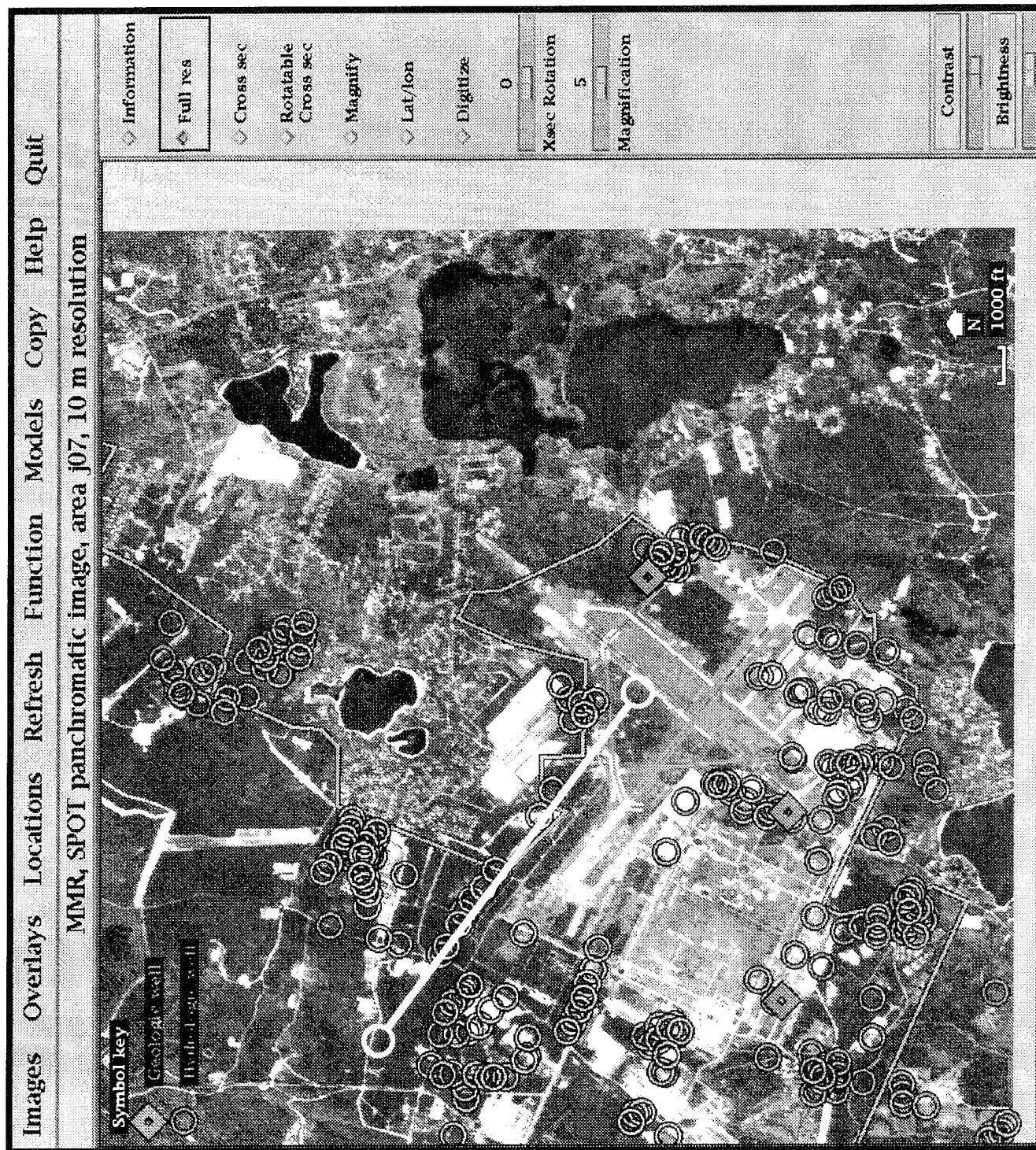


Sample of online hydrologic well information which can be accessed by clicking on the well location with the mouse.

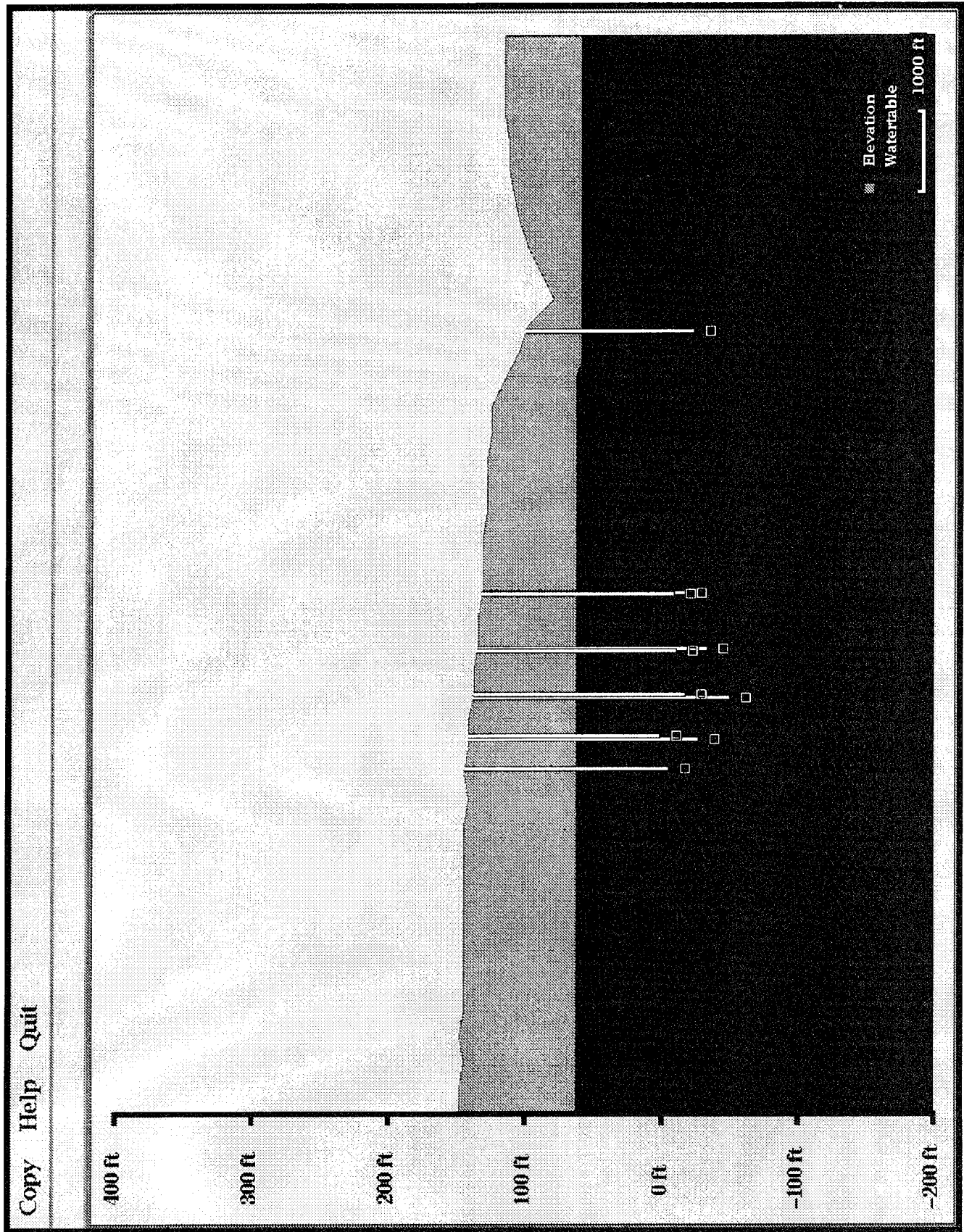


Sample of online geologic well information which can be accessed by clicking on the well location with the mouse. Information regarding the sampling results at any depth can be accessed from this display by selecting the corresponding depth bracket with the mouse.

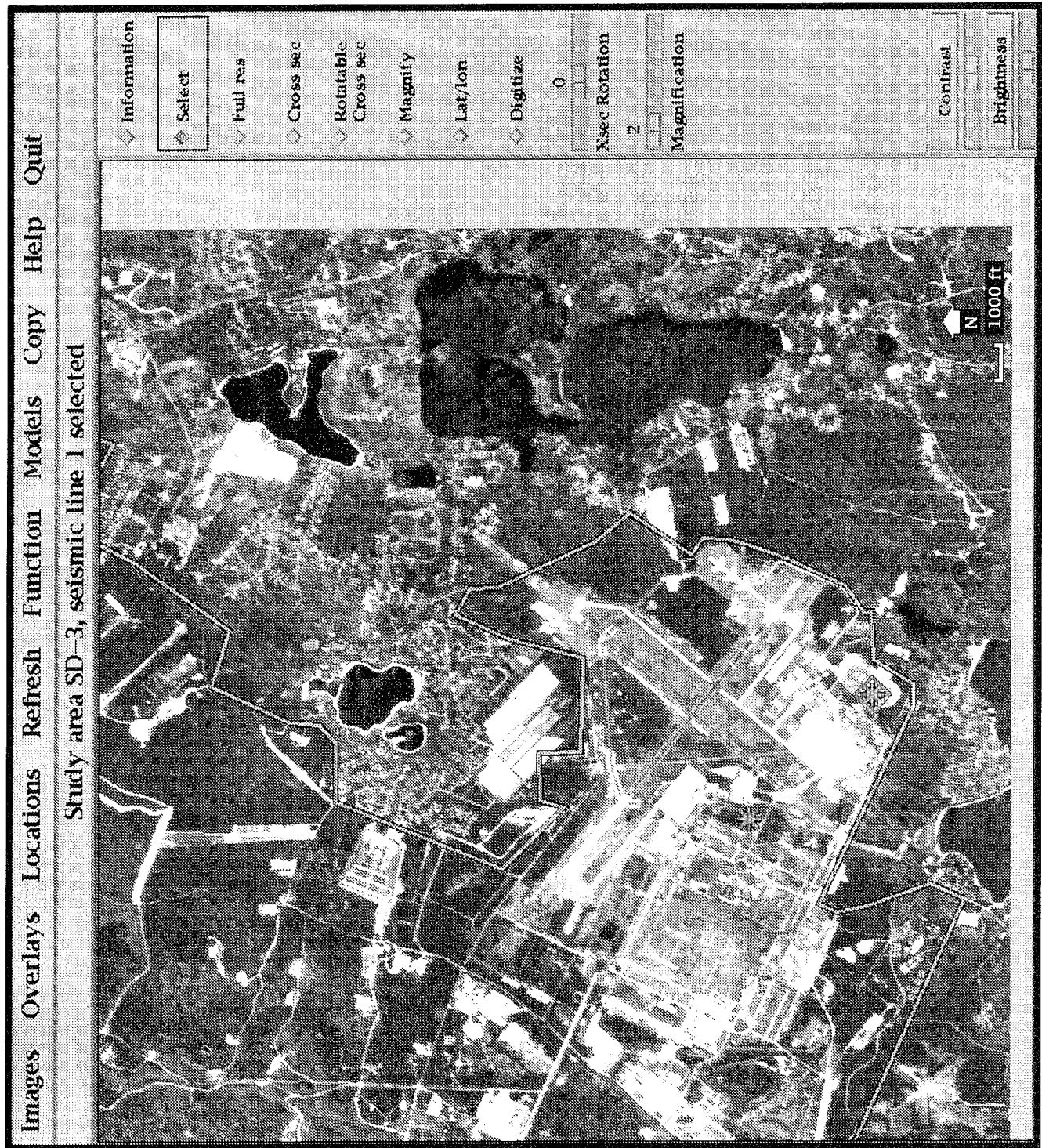




Full resolution SPOT image of the southeast corner of MMR with superimposed MMR boundary and locations of wells, showing an interactively selected line through several hydrologic well locations.



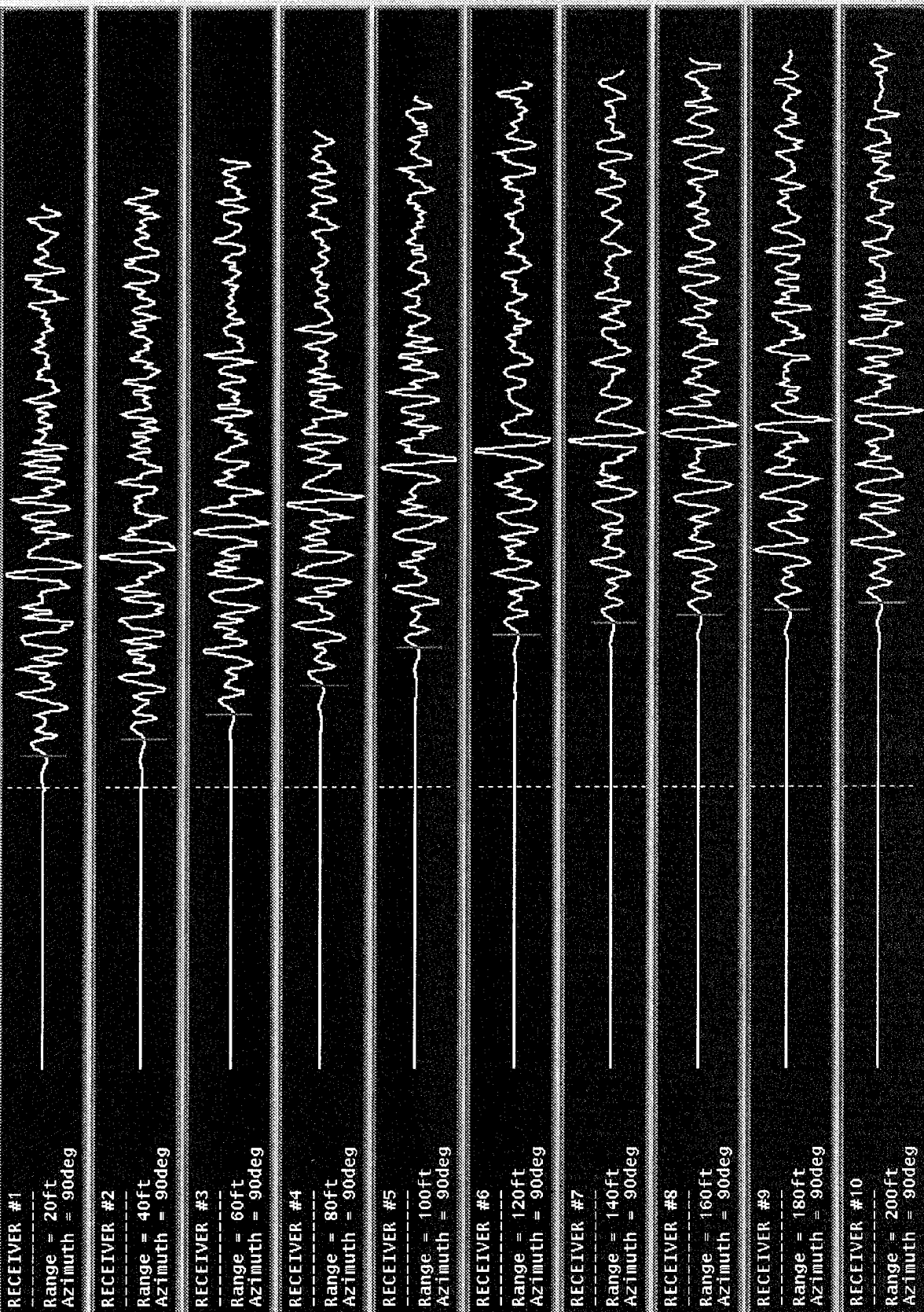
Vertical subsurface section along the interactively selected line from the previous figure showing the variations in topography, depth to water table and depth of penetration of the hydrologic wells encountered along that line.



Full resolution SPOT image of the southeast corner of the MMR with superimposed MMR boundary and locations of seismic surveys (asterisks).

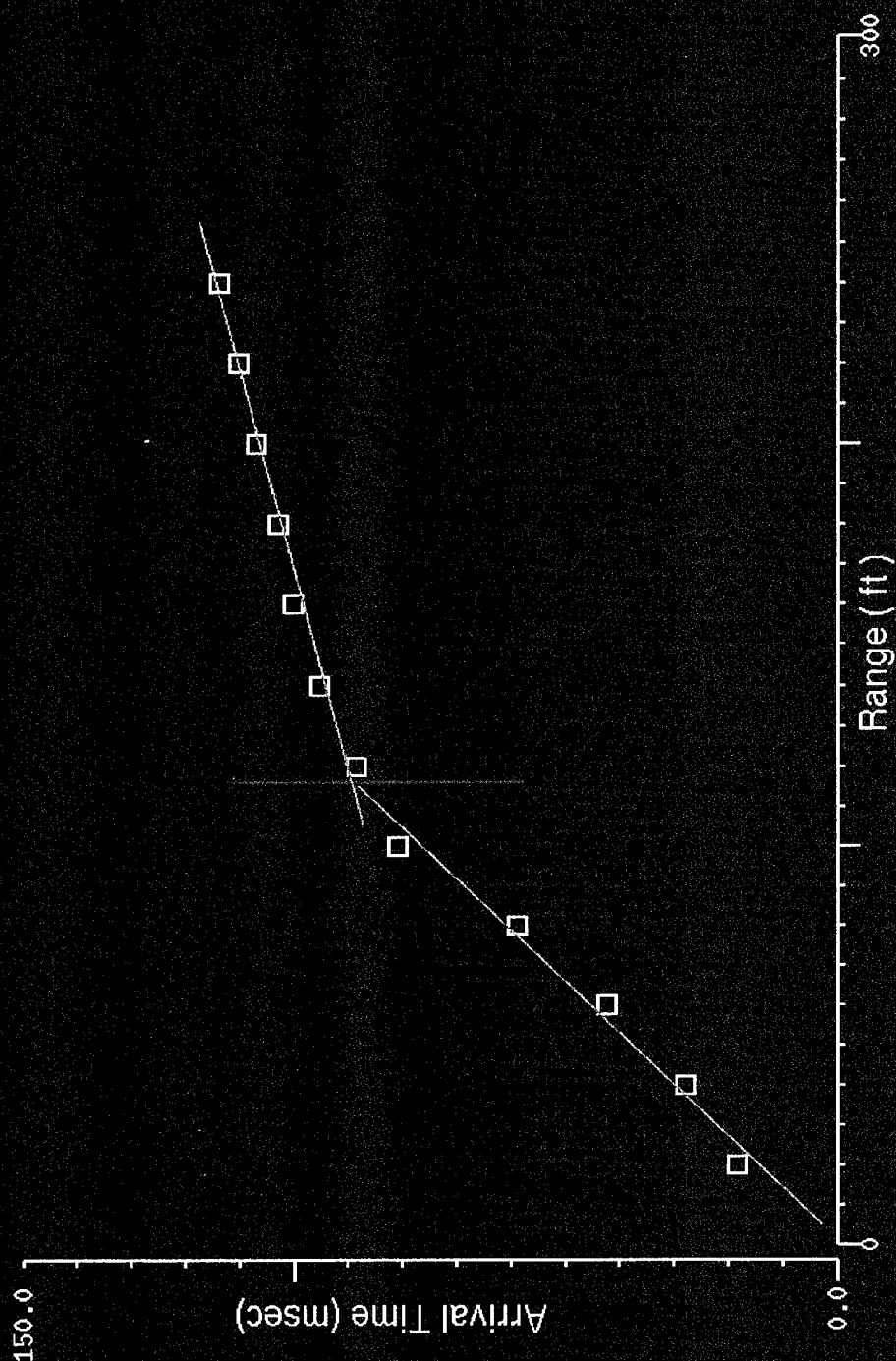


## Seismic Line 1 - Pick mode



Seismic profile for the selected survey showing the recorded data in order of increasing distance from the source. The dashed vertical line denotes the shot time while the short vertical lines through each trace denote the interactively selected signal onset times.

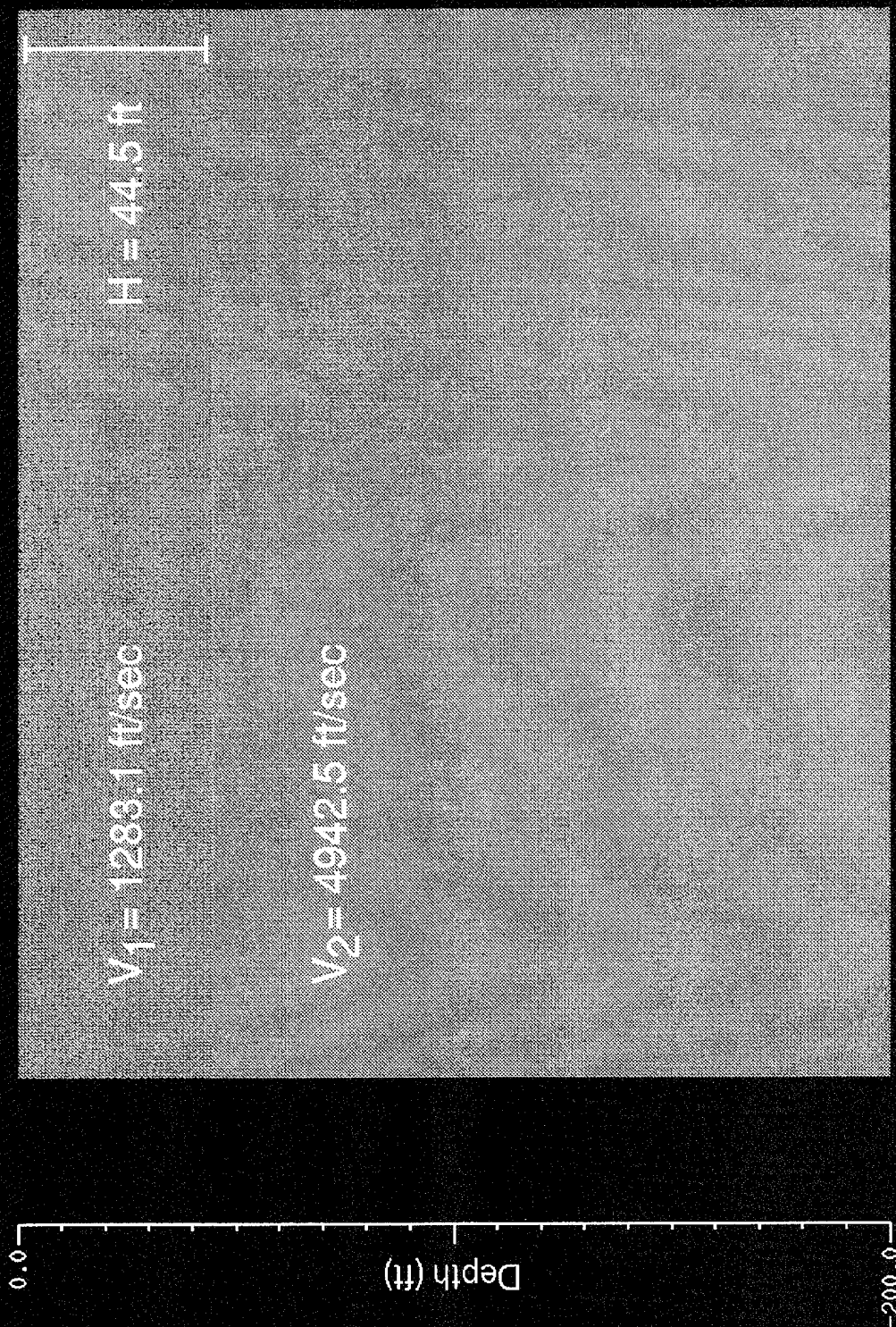
Velocity 1 = 1283.1 ft/sec, Velocity 2 = 4942.5 ft/sec



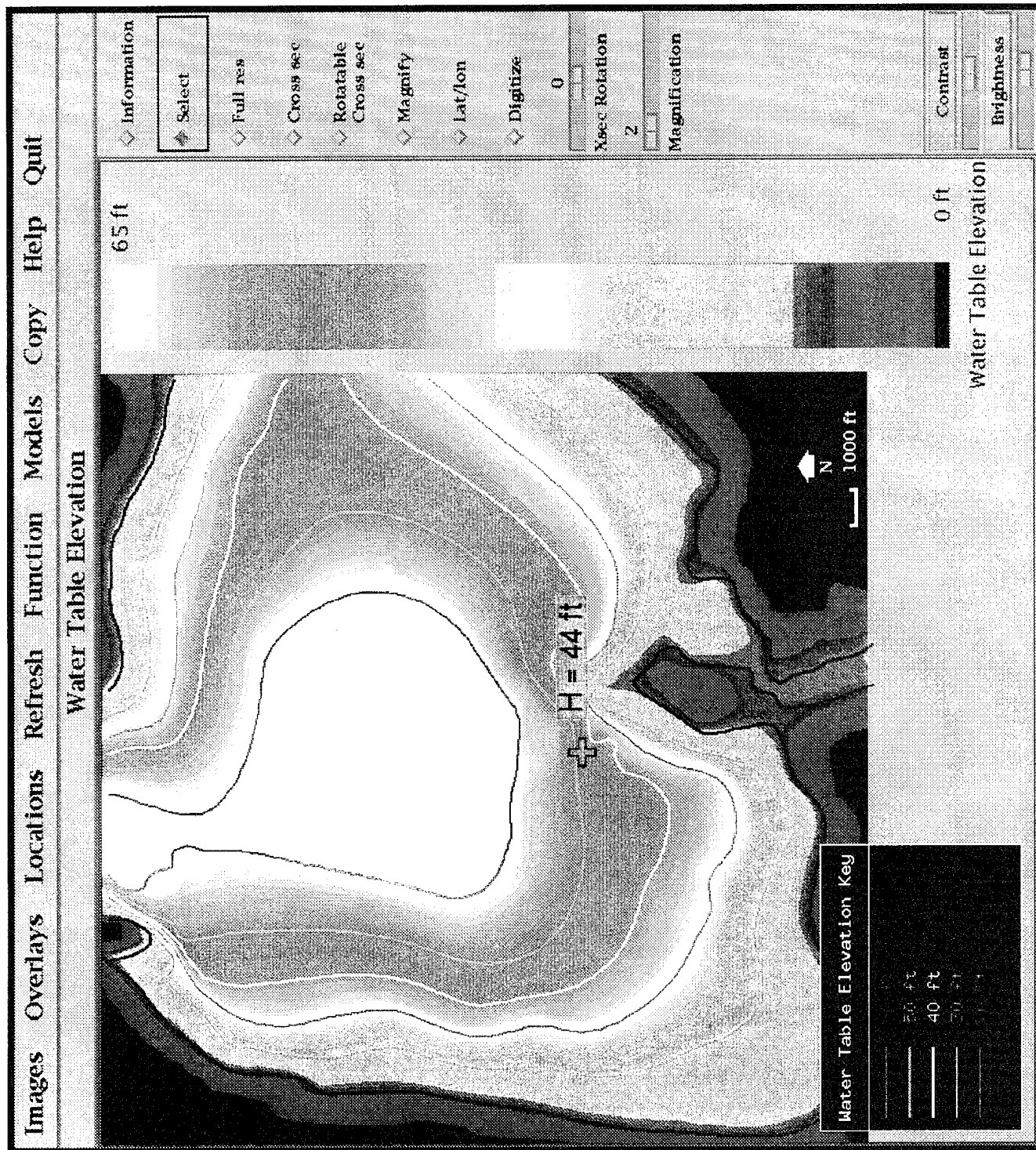
Travel time curve showing the selected seismic first arrival times from the previous figure as a function of distance from the source. The vertical line denotes the interactively selected critical distance separating arrivals with different characteristic velocities.

Quit

# Velocity Model

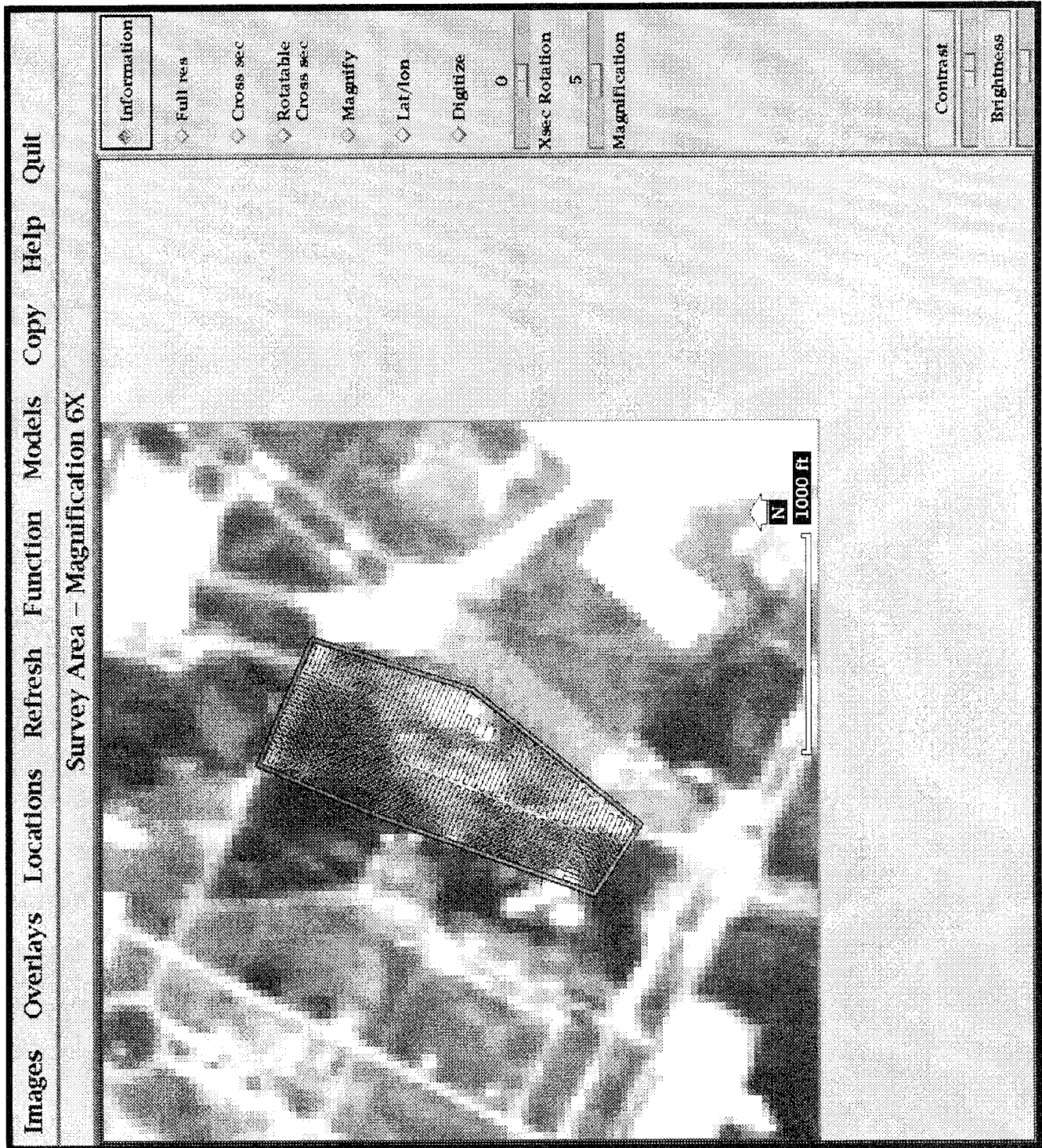


Subsurface vertical velocity model along the selected seismic survey line. This model was automatically determined using the travel time data and critical distance estimate shown on the previous figure.

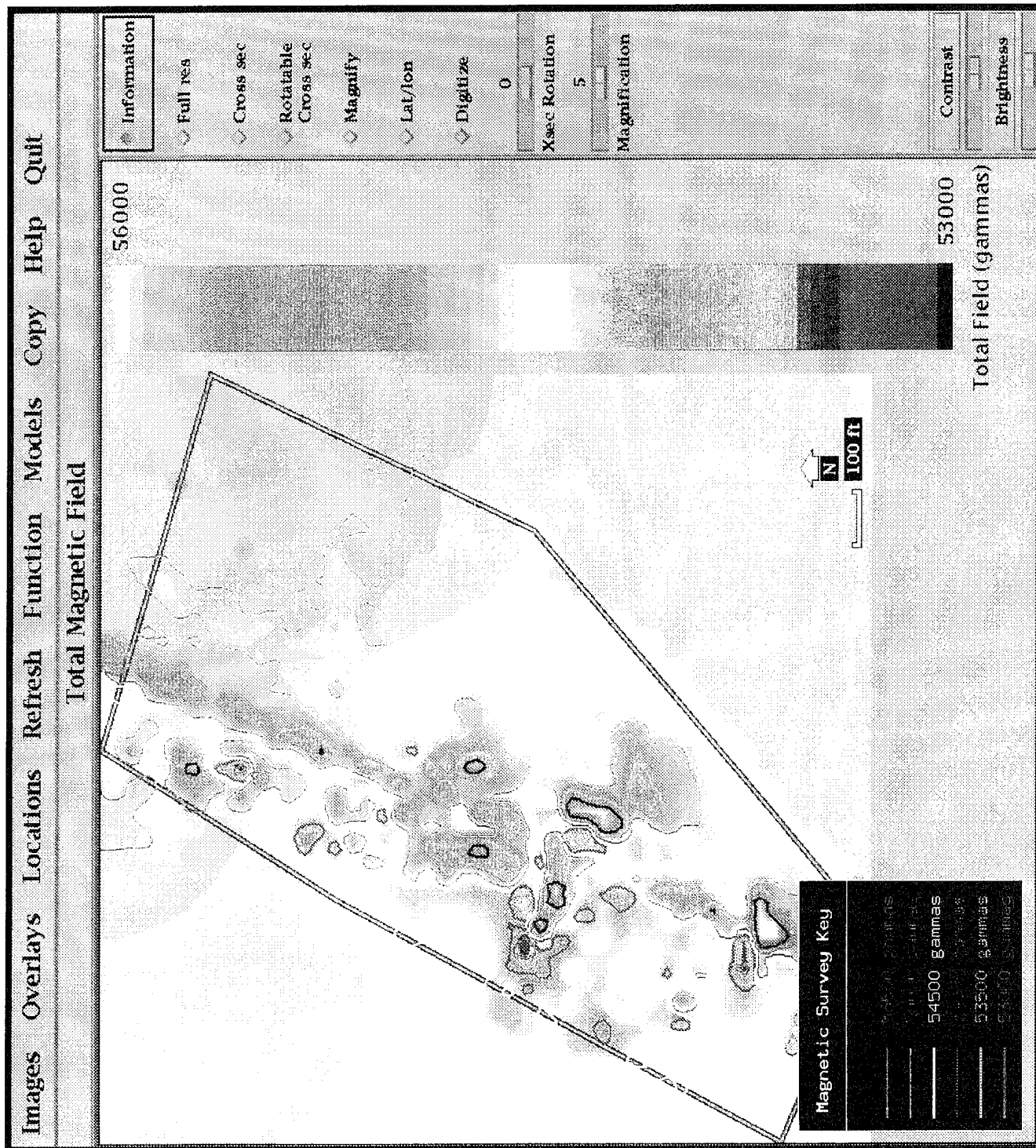


Comparison of the color-coded hydrologic map of depth to water table for Western Cape Cod with the superimposed water table depth (cross) determined from the seismic survey model shown in the previous figure.

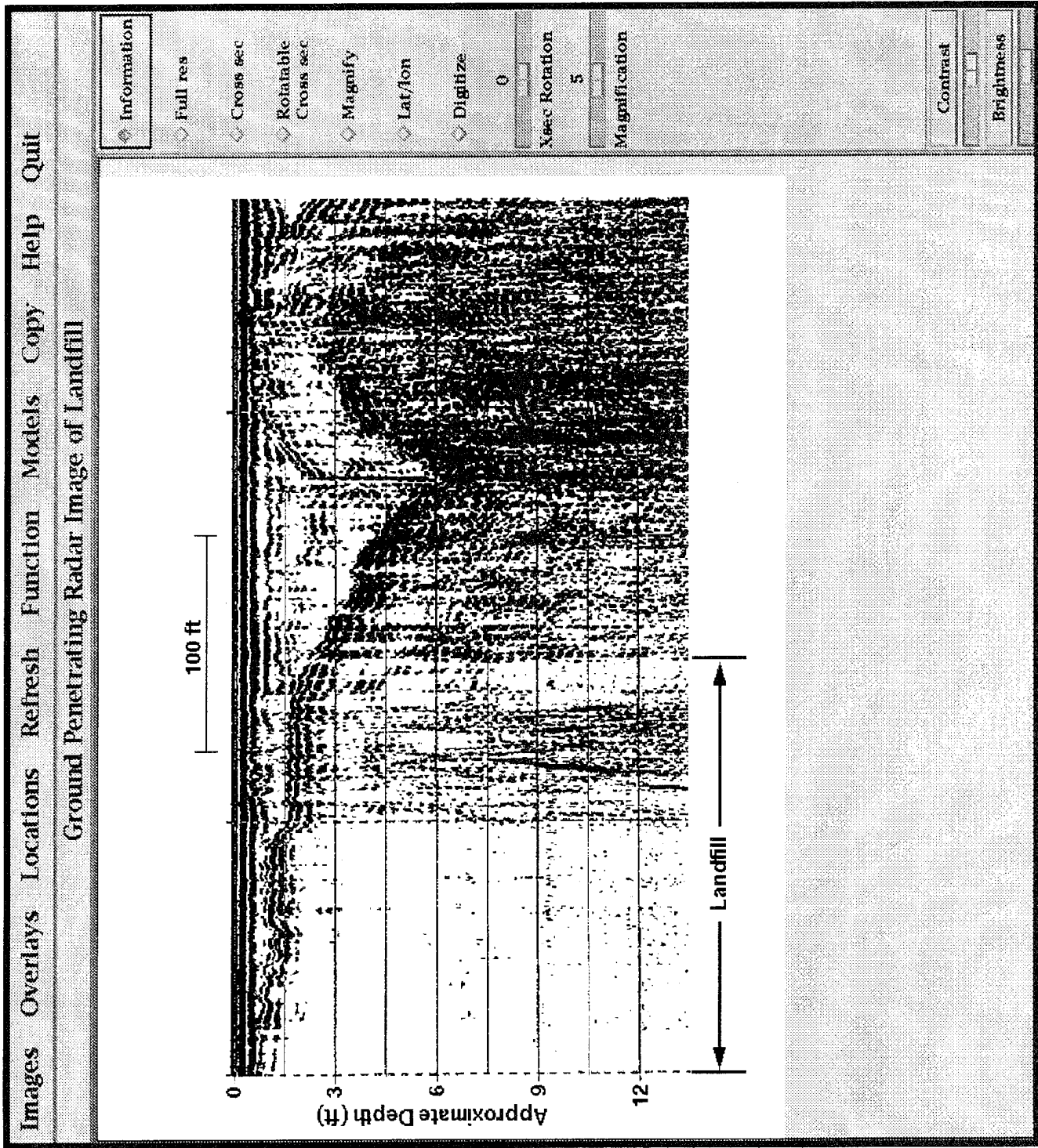




Magnified (X6) full resolution SPOT image of MMR landfill Study Area LF-2, showing locations of magnetic survey lines.



Color-coded contour plot of total magnetic field variation across the LF-2 Study Area shown on the previous figure.



Ground penetrating radar (GPR) profile along a survey line across landfill Study Area LF-2.

Copy Help Quit

Modelling Parameters

Elapsed time (days) 500

Separation (m) 300

Source depth (m) 30

Sensor depth (m) 15

Velocity (m/day) .10


Dispersion ( $m^2/day$ ) .010

Step time increment (days) 100

Step time start (days) 0

Advective-dispersive transport modeling result illustrating the time-dependent growth of a contaminant plume in a homogeneous groundwater system,  $T = 500$  days.



Copy Help Quit	
	<b>Modelling Parameters</b> Elapsed time (days) 2000 Separation (m) 300 Source depth (m) 30 Sensor depth (m) 15 Velocity (m/day) .10 Dispersion ( $m^2/day$ ) .010
	Step time increment (days) 100 Step time start (days) 0

Computed contaminant plume boundary,  $T = 2000$  days.

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